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A study was made to determine the extent to which scores representing pupils' status on certain developmental factors can predict the achievement in reading, arithmetic, and the median of the battery of achievement tests. The study covered a period of four years during which the same group of pupils was studied in the third, fourth, fifth, and sixth grades. Data was obtained on several variables representing physical, intellectual, social, and emotional aspects of development; factor analysis yielded the scores used to predict achievement. The variables included: age in months, height in inches, weight in pounds, right and left hand grips in pounds, standing broad jump, 50-yard dash, Otis Intelligence Score, average reading and arithmetic scores on Stanford Tests, sociometric choices, stability score on SAS Personality Test, sex, and Agility Test of Physical Fitness Test.

The findings suggested that there are many factors influencing the prediction of achievement. Scores representing physical performance, physical growth, and emotional development factors made the largest contribution of the non-intellectual factors but their contribution to the prediction of achievement was not significant; the intelligence factor made the major contribution. It is possible that the developmental factors might make a more significant contribution to the prediction of achievement for specific pupils and for a more extreme group than used in this study.

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LONGITUDINAL ANALYSIS OF PUPIL PROGRESS IN A PUBLIC SCHOOL(1)

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NEW YORK UNIVERSITY
SCHOOL OF EDUCATION

ED001342

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(1) Project jointly supported by New York State Education Department, New York University and Roslyn (Long Island, New York) Public Schools.

The Problem

The purpose of this study was to determine the extent to which scores representing pupils' status on certain developmental factors predict the achievement in reading, arithmetic, and the median of a battery of achievement tests. This study covers a period of four years during which the same pupils in the Roslyn Public Schools were studied in the third, fourth, fifth and sixth grades.

The theoretical frame of reference is the organismic development theory which proposes that the total developmental status of children is an important factor in their academic achievement and intellectual development. Olson and Hughes (1949)[1] have been prominent in this field and have reported some success in predicting achievement from a total Organismic Age score. Klausmeier (1958)[2] on the other hand has suggested that the organismic concept adds little to the prediction of academic achievement.

Studies of these children in the third and fourth grades have shown that emotional and intellectual aspects of development differentiate high and low achievers.[3]

The approach in studying this problem has been to obtain data on several variables purporting to represent the physical, intellectual, social, and emotional aspects of development, to factor analyze these data, and finally to compute standard scores (Mean=5.0, SD=1.0) for each variable comprising each factor. The standard scores were used to compute a score for each developmental factor and the factor scores were used to predict achievement.

The Research Design

Data on the following variables were collected for 193 pupils (boys and girls) in the Roslyn Public Schools. The sample represents all of the pupils in Roslyn who were previously included in the study in 1960-61 1961-62, and 1962-63. 107 boys and 86 girls were in the sample. All pupils were tested in the third, fourth, fifth and sixth grades.

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1. W.C. Olson, Child Development, Boston: D.C. Heath, 1949.

2. H. Klausmeier, et al, "Comparison of Organismic Age and R gression Equations in Predicting Achievement in Elementary School," J. Ed. Psych. 1958, 49:182-186.

3. "Use of a Developmental Index to Predict Pupil Achievement." Report of Experimental Program at UFSD #3, 1961-62.

The variables for which data were collected were:

1. Age in months
2. Height in inches
3. Weight in pounds
4. Developmental channel on the Wetzel Grid
5. Right hand grip in pounds
6. Left hand grip in pounds
7. Standing broad jump
8. 50 - yard dash
9. Otis Intelligence Score (most recent)
10. Average reading score on previous years Stanford Achievement Test
11. Average arithmetic score on previous years Stanford Achievement Test
12. Sociometric choices
13. Social approachability score on SAS Personality Test[4]
14. Stability score on SAS Personality Test
15. Sex
16. Agility Test of New York State Physical Fitness Test was included in 1963-64.

The data for these varibles were intercorrelated and a factor analysis was run using the varimax program (University of California version) on the IBM 7094 computer at New York University. Index scores were computed for each factor by computing standard scores for each variable and then combining the scores for the relevant variables comprising each factor. The standard scores for physical growth and physical performance variables were computed separately for boys and girls because it was found that these variables loaded on sex. The form of the standard scores was:

$$5.0 + \frac{(X - M)}{\sigma}$$

Thus, the range of standard scores for each variable was from 2.0 to 8.0.

The scores for each factor were computed. These factor scores were used in the Wherry-Doolittle Multiple Correlation against the 1964 achievement scores in reading, arithmetic and the battery median from the Stanford Achievement Test.

Findings

1. The factor structure remained fairly constant over the four year period. The factors and the loadings on each factor can be seen in Tables 1, 2, 3 and 4.

The factors that were identified were intellectual development, physical performance, physical growth, emotional development and physical development.

4. D.E.P. Smith, University of Michigan, 1956 (monograph).

The comparison of the loadings on each factor are presented in Table 5. Although there is much consistency, the loadings on the physical growth, physical performance and emotional development factors show changes as the pupils become older. The variance for each factor can be seen in Table 6. The means and standard deviations for each variable for the four years are found in Table 7.

2. The prediction of achievement of the pupils in the sixth grade can be seen in Table 8. The regression equations and multiple correlations to predict the battery median, reading average and arithmetic average were computed using (1) the 1964 developmental scores, (2) the 1961 developmental scores, and (3) the pupils' 1961 Stanford achievement scores. In addition, the regression equations were computed with the score for the intellectual factor omitted.

The highest prediction was achieved using the 1964 developmental score (R=.73 to .81), while the 1961 developmental scores and achievement scores yielded multiple correlations of .55 to .68. In all instances the intellectual factor made the greatest contribution to the prediction. When the intellectual factor was omitted, only the predictions using 1964 developmental scores yielded significant correlations. The multiple correlations were low (.18 to .24). The physical performance and emotional development factors were the factors that contributed to the prediction.

3. When the change in the developmental factors over the four years was related to change in achievement, the intellectual factor was the only factor to show differences. The comparison was made by comparing those pupils whose index score changed plus .5 standard score units with those whose score changed -.5 score units. These comparisons can be seen in Table 9.

Discussion

The most interesting finding of the study is the relative stability of the factor structure of the developmental factors. Changes in the loadings on some of the variables on certain factors suggests that variation in the contribution of variables to a particular factor does not sufficiently alter the structure of the factor to make a difference in the over-all picture. The one exception might be the differentiation of the physical growth factor into two factors, physical development and physical growth. One conjecture about these findings is that most of the significant developmental changes involving the total organism have taken place prior to the 3rd grade, when the children were already 8 years old.

Although it is possible to describe the various factors of development discretely and accurately, the findings of the study indicate that the use of scores representing physical performance, physical growth and emotional development factors does not contribute significantly to the prediction of achievement. The intellectual factor makes the major contribution in the prediction of achievement as might be expected.

These results suggest that there are many factors influencing the prediction of achievement which probably counterbalance the effect of certain organismic changes for the group as a whole. The physical performance and emotional development factors make the largest contribution of the non-intellectual factors but their contribution is rather small. It is possible that the developmental factors might make a more significant contribution to the prediction of achievement for specific pupils and for more extreme groups.

Comments on the Use of the Factor Analysis Approach in Longitudinal Studies

1. The factor analysis, computed each year of the study, enables the investigator to examine the group patterns of development. In this way it is possible to identify the major areas of development and to ascertain when new developmental factors emerge. This was seen in this study when the physical growth factor gave rise to another factor related to physical growth, which we called physical development because the Wetzel Developmental score had a high loading on the factor. Examination of the factor loadings on the developmental factors from year to year allows the researcher to notice possible shifts in developmental patterns before different developmental factors are identified. We were able to make a fairly definitive conclusion about the stability of developmental factors in elementary school children.

2. The factor analysis provided the base for the computation of the developmental score for each child on each factor. When these scores were used in the multiple prediction analysis, we were able to study the prediction of achievement using various combinations of developmental factors. The developmental scores, computed as standard scores, made it possible to examine the amount of change of each child from year to year on each factor. The method used in this study suggests that although the total developmental structure is fairly stable, there is still quite a bit of variability in academic or school performance. Perhaps, an extension of the factor analysis approach to groups showing greater variability in achievement (the extreme groups) would provide more conclusive data to help explain pupil achievement. Our approach provides both hope and questions, outcomes which are essential purposes of scientific inquiry.

RCB/wyb
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TABLE I

FACTOR LOADINGS ON DEVELOPMENTAL FACTORS

1960-61 (3rd Grade)

VARIABLES	NAME OF FACTOR				
	Intellectual	Physical Performance	Physical Growth	Emotional	h^2
Age	-.105	-.338	-.031	-.039	.128
Height	.002	-.102	-.438	-.050	.205
Weight	-.070	-.139	-.914	.007	.860
Wetzel Grid	.021	-.033	.612	.047	.378
Right Grip	-.011	-.702	-.227	.014	.545
Left Grip	-.050	-.669	-.274	-.013	.525
Standing Broad Jump	.108	-.548	.147	-.048	.336
Dash	.042	.423	-.089	-.045	.195
Para M.	.887	.035	-.018	.011	.788
Word M.	.886	.021	-.046	.129	.804
Spell.	.821	.076	.037	.073	.687
Lang.	.863	.065	-.008	.067	.754
Arith. R.	.772	-.139	.099	-.364	.758
Arith. C.	.652	-.098	.068	-.400	.599
Bat. Med.	.985	-.011	.016	.071	.976
Otis Mental Ability Score	.577	-.041	-.119	-.198	.388
Social Approach.	.254	.032	-.058	-.396	.226
Stability	-.011	-.056	-.121	-.364	.150
Sociometric	.412	-.211	.145	-.111	.248
Sex	.059	.477	.019	-.022	.232
VARIANCE	57%	19%	17%	7%	

▱ = Variables used in computing the index score

TABLE 2

FACTOR LOADINGS ON THE DEVELOPMENTAL FACTORS

1961-62 (4th Grade)

VARIABLES	NAME OF FACTOR				
	Physical Growth	Intellectual	Physical Performance	Emotional	h^2
Age	-.052	-.152	.166	-.031	.054
Height	.654	-.058	.261	.124	.515
Weight	.991	-.004	.056	-.023	.986
Wetzel Channel	-.630	-.050	.160	.184	.459
Right Grip	.505	-.120	.590	.034	.619
Left Grip	.562	-.026	.511	.071	.583
St. Broad Jump	-.037	.059	.712	-.009	.512
50-yard Dash	.070	.032	.776	.068	.613
Battery Median	-.024	.955	.026	..008	.913
Otis IQ	.061	.635	.007	-.008	.407
Social Approach	.064	.158	.022	-.563	.347
Stability	.129	.082	.093	-.574	.361
Sociometric	-.190	.329	.362	-.139	.295
Reading Average	.020	.883	.043	.009	.782
Arithmetic Average	-.067	.807	.062	-.507	.663
VARIANCE	30.25%	36.20%	24.54%	9.01%	

▱ = Variables used in computing the index score.

TABLE 3

FACTOR LOADINGS ON DEVELOPMENTAL FACTORS

1962-63 (5th Grade)

VARIABLE	FACTOR I Physical Development	FACTOR 2 Intellectual Development	FACTOR 3 Physical Performance	FACTOR 4 Physical Growth	FACTOR 5 Emotional Development	h^2
Age	.078	-.211	-.166	.099	-.121	.102
Height	.015	..006	-.164	.927	.060	.891
Weight	-.644	.022	-.063	.717	-.088	.940
Wetzel Grid	.912	-.025	-.023	-.085	.101	.874
Right Grip	-.281	-.012	-.645	.447	-.056	.699
Left Grip	-.334	-.074	-.578	.457	.057	.664
St. Bd. Jump	.127	.324	-.658	.054	-.061	.457
50-yard Dash	-.092	.026	.618	-.016	.018	.403
Intelligence	-.036	.852	.021	-.035	-.041	.730
Social Approach.	-.050	.012	.111	.054	-.580	.345
Stability	-.138	..137	-.066	-.023	-.416	.216
Sociometric	.063	.169	-.200	-.201	-.313	.211
Reading Aver.	.043	.788	-.037	.071	-.138	.649
Arith. Aver.	-.003	.682	-.064	-.008	-.157	.495
Sex	.144	-.059	.473	.005	-.217	.295
VARIANCE	19.17%	24.98%	23.63%	22.88%	9.34%	

▱ = Variables used in computing the index score

TABLE 4

FACTOR LOADINGS ON DEVELOPMENTAL FACTORS

1963-64 (6th Grade)

VARIABLE	FACTOR 1 Physical Growth	FACTOR 2 Intellectual Development	FACTOR 3 Physical Performance	FACTOR 4 Emotional Development	FACTOR 5 Physical Development	h^2
Age	-.479	.172	.047	.026	.313	.360
Height	-.825	.017	.070	.038	.122	.703
Weight	-.695	.002	.060	.004	-.682	.952
Wetzel Grid	-.203	.018	-.118	.034	-.826	.744
Right Grip	-.805	-.033	-.294	-.100	-.168	.773
Left Grip	-.829	-.024	-.255	-.096	-.155	.787
St. Bd. Jump	-.225	.041	-.818	-.109	.050	.735
50-Yard Dash	-.130	-.011	-.779	-.025	-.034	.625
Agility	.038	.101	-.452	-.013	-.069	.221
Bat. Median	.014	.957	-.079	-.090	-.051	.932
Intelligence	-.153	.880	-.010	.034	.111	.812
Soc. Approach.	.003	.046	.003	-.828	.043	.690
Stability	-.043	.175	.044	-.670	-.131	.501
Sociometric	.101	.078	-.243	-.380	-.209	.263
Reading Aver.	-.001	.891	-.076	-.074	-.005	.806
Arith. Aver.	.050	.845	-.070	-.212	-.054	.769
Sex	-.355	-.025	-.217	-.520	.243	.504
VARIANCE	26.86%	29.38%	15.94%	14.76%	13.06%	

▱ = Variables used in computing the index score

TABLE 5

LOADINGS ON

VARIABLES CONTRIBUTING TO EACH DEVELOPMENTAL FACTOR

Intellectual Factor

1960-61		1961-62		1962-63		1963-64	
Par. M	.887	Reading Avg.	.883	Reading Avg.	.788	Reading Avg.	.891
Word M	.886	Arith. Avg.	.807	Arith. Avg.	.682	Arith. Avg.	.844
Spell.	.821	Bat. Med.	.955	Otis IQ	.852	Bat. Med.	.957
Lang.	.863	Otis IQ	.635			Otis IQ	.880
Arith R.	.772						
Arith C	.652						
Bat. Med.	.985						
Otis IQ	.577						

Physical Growth Factor

1960-61		1961-62		1962-63		1963-64	
Height	-.428	Height	.654	Height	.927	Height	.825
Weight	-.914	Weight	.991	Weight	.717	Weight	.695
Wetzel Grid	.012	Wetzel	-.630	R. Grip	.447	R. Grip	.805
				L. Grip	.457	L. Grip	.829

Physical Development Factor

1960-61	1961-62	1962-63		1963-64	
NOT IDENTIFIED	NOT IDENTIFIED	Weight	-.644	Weight	-.681
		Wetzel	.912	Wetzel	.826

Physical Performance Factor

1960-61		1961-62		1962-63		1963-64	
R. Grip	-.702	R. Grip	.590	R. Grip	-.645	St. Bd. Jump	-.818
L. Grip	-.669	L. Grip	.511	L. Grip	-.578	50-yd. Dash	-.779
St. Bd. Jump	-.548	St. Bd. Jump	.712	St. Bd. Jump	-.658	Agility Run	-.452
50 yd. Dash	.428	50 yd. Dash	.776	50 yd Dash	.618		

Emotional Factor

1960-61		1961-62		1962-63		1963-64	
Social App.	-.396	Social App.	-.563	Social App.	-.580	Social App.	-.828
Stability	-.364	Stability	-.574	Stability	-.416	Stability	-.670

TABLE 6

VARIANCE OF EACH FACTOR IN DEVELOPMENTAL INDEX

	1960-61	1961-62	1962-63	1963-64
Intellectual	57%	36%	25%	29%
Physical Performance	19%	25%	24%	16%
Physical Growth	17%	30%	23%	27%
Emotional Development	7%	9%	9%	15%
Physical Development	---	---	19%	13%

TABLE 7

MEANS AND STANDARD DEVIATION OF VARIABLES STUDIED

VARIABLE	4th Grade 1961-62		5th Grade 1962-63		6th Grade 1963-64	
	Mean	SD	Mean	SD	Mean	SD
Age (months)	113.3	4.4	125.2	4.5	137.08	4.11
Height (inches)	55.2	2.2	55.2	2.4	57.55	2.64
Weight (pounds)	71.6	12.6	77.4	13.8	85.35	16.26
Wetzel Channel	5.0	1.8	5.1	1.9	5.38	1.90
Right Grip	36.3	8.2	35.6	8.8	42.91	10.54
Left Grip	33.9	8.2	32.2	8.6	37.80	10.41
St. Bd. Jump	54.3	6.9	56.1	6.6	58.51	6.87
50-Yard Dash	9.1	.7	8.6	.6	8.34	.62
Otis I.Q.	106.3	13.6	114.5	10.2	114.97	9.93
Reading Aver.	4.7	1.3	6.1	1.3	7.54	1.56
Arith. Aver.	4.2	.8	6.1	1.1	6.53	1.04
Stability (SAS)	14.0	6.8	16.3	6.8	16.65	6.03
Soc. Approach (SAS)	25.7	4.8	27.1	2.4	26.96	4.51
Sociometric Choice	4.9	3.0	4.9	2.8	5.09	2.86
Agility Test	----	---	----	---	14.13	3.40
	N = 291		N = 259		N = 218	

TABLE 8

REGRESSION EQUATIONS TO PREDICT ACHIEVEMENT IN THE SIXTH GRADE

BATTERY MEDIAN:

1964 Developmental Index

1.783 Intelligence + .157 Emotional - 1.402

R = .8153

adj R = .8131 *

omitting Intellectual Factor

.504 Phys. Perf. + .535 Emotional + 3.105

R = .2402

adj R = .2297 *

1961 Developmental Index

1.790 Intellectual -.8934

R = .6890

adj R = .6890 *

Omitting Intellectual Factor

.3147 Emotional + 6.6958

R = .1270

adj R = .1270

1961 Achievement Scores

.540 Battery Median + .706 Reading + 3.563

R = .6294

adj R = .6243 *

* Significant at 1% level

TABLE 8

(continued)

READING AVERAGE:

1964 Developmental Index

2.053 Intellectual -.1382

R = .7900

adj R = .7893 *

Omitting Intellectual Factor

.584 Phys. Perf. + .514 Emotional + 3.386

R = .2081

adj R = .1823 **

1961 Developmental Index

.276 Phys. Perf. + 1.936 Intellectual - 2.464

R = .6458

adj R = .6434 *

Omitting Intellectual Factor

.360 Phys. Perf. + 7.056

R = .1020

adj R = .1020

1961 Achievement Scores

1.258 Reading + 3.984

R = .6030

adj R = .6030 *

* Significant at 1% level
** Significant at 5% level

TABLE 8

(continued)

ARITHMETIC AVERAGE:

1964 Development Index

1.610 Intellectual + .136 Emotional + .320 Phys. Develop. - 2.208

R = .7353

adj R = .7303 *

Omitting Intellectual Factor

.540 Phys. Perf. + .4761 Emotional + .398 Phys. Develop. + 1.053

R = .2386

adj R = .2168 **

1961 Developmental Index

.193 Phys. Perf. + 1.588 Intellectual + .194 Emotional - 1.997

R = .6267

adj R = .6216 *

Omitting Intellectual Factor

.269 Phys. Perf. + .372 Emotional + 4.864

R = .1707

adj R = .1551

1961 Achievement Scores

1.006 Bat. Med. + .369 Arithmetic + 3.181

R = .5537

adj R = .5504 *

* Significant at 1% level
** Significant at 5% level

TABLE 9

CHANGE IN ACHIEVEMENT RELATED TO CHANGE IN EACH DEVELOPMENTAL FACTOR

		CHANGE IN BATTERY MEDIAN		CHANGE IN READING AVERAGE		CHANGE IN ARITHMETIC AVERAGE	
		M	SD	M	SD	M	SD
Intellectual Develop.	+.5 (N=23)	5.6	1.4	6.4	1.3	5.4	1.7
Intellectual Develop.	-.5 (N=43)	3.8*	2.0	3.9*	2.0	3.9*	2.1
Physical Performance	+.5 (N=38)	4.5	1.4	4.6	2.0	4.7	1.5
Physical Performance	-.5 (N=41)	4.3	.4	4.8	1.6	4.5	1.5
Physical Growth	+.5 (N=36)	4.7	1.4	5.2	.9	4.8	2.0
Physical Growth	-.5 (N=28)	4.4	1.3	4.6	1.7	4.8	1.1
Emotional Development	+.5 (N=36)	4.7	.5	5.2	2.1	4.8	1.7
Emotional Development	-.5 (N=57)	4.7	1.5	4.9	1.7	4.9	1.8

* Difference Significant at 1% level

Battery Median t = 4.29
Reading Average t = 5.29
Arithmetic Average t = 3.12